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(71) Applicant: DRILLING & SERVICE U.K. LIMITED
Tuffley Crescent
Gloucester GL1 5NG(GB)

(72) Inventor: Fuller, John Michael
Woodlands Downend Horsley
Nailsworth Gloucestershire(GB)

(74) Representative: Shaw, Laurence
George House George Road
Birmingham, B15 1PG(GB)

(54) Tools for underground formations.

(57) A tool for an underground formation e.g. an eccentric hole opener, has an eccentric portion the end face of which has cutting elements, preferably poly-crystalline diamond compacts. According to the invention the elements are distributed about the end face in an arrangement to reduce the imbalance in horizontal cutting forces caused by the eccentricity of the tool.

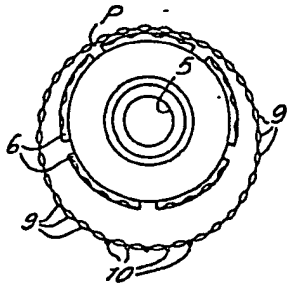

FIG.2.

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DRILLING & SERVICE U.K. LIMITED

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TOOLS FOR UNDERGROUND FORMATIONS

The invention relates to tools for drilling or enlarging the diameter of a deep hole by rotary motion of a drilling assembly in an underground formation for example to extract oil, gas, water, minerals or geothermal energy, or to inject gas or liquids to pressurise a reservoir or for waste disposal.

It is sometimes necessary to make a hole in the formation having a diameter larger than the internal diameter of the well head and/or conductor pipe and/or casing pipe leading to the required section of a larger hole. There is also a need to enlarge the diameter of a pilot hole already drilled.

A well known tool for meeting these requirements is a so-called "eccentric blade hole-opener" which has no moving parts. This normally comprises a centralising means and a cutting means, the latter being uppermost in use of the tool. The centralising means may carry or include a pilot drilling means. The cutting means comprises a plurality of cutting elements

projecting normally on one side only. The omission of cutting means on the other side enables the tool to pass through the well head or casing having a smaller internal diameter than that made by the cutting means. This is possible, because the centralising means ceases to function while passing through the well head or casing and out of the pilot hole.

Unfortunately because the cutting elements are concentrated on one side, or predominantly on one side, the forces on them have a resultant lateral component which must be largely balanced by the forces on the centralising means. These forces can cause: extra friction between the centralising means and the formation, wear of the centralising means and wear of the wall of the pilot hole. The latter can enable the tool to rotate about the wrong axis leading to irregular hole opening of an undersized or variable diameter.

It is an object of the invention to provide a tool such as an eccentric hole opener in which the cutting forces generated in use have a relatively small resultant lateral component.

According to one aspect of the invention, a tool for the purpose specified comprises an annular body

having means at least at one end whereby it may be connected to other units of the bottom hole assembly of a drill string, the connecting means being arranged such that the element is mounted eccentrically on the bottom hole assembly, in which cutting elements are distributed about an end face of the body in an arrangement to reduce imbalance of the lateral components of the cutting forces generated in use of the hole opener.

The cutting elements may be arranged about the end face in an appropriate position and/or attitude. One arrangement is to distribute the cutting elements approximately evenly close to the periphery of the end face. The exact radial distances of the cutters from the central axis of the hole opener are individually selected to determine the cutting pattern and equalise their wear life as far as possible. Depending on the requirements of use, the cutting elements may be evenly or unevenly spaced around the periphery. The sum of the horizontal cutting forces generated in use of the tool comprises a turning couple + an imbalance horizontal component. By the features of this invention the imbalance component may be reduced to be less than 50%, preferably about 20% of the total horizontal cutting force.

The eccentric hole opener of the invention may

take a variety of forms. Although the body may be round as seen in plan, in practice, it may not be necessary to have a complete peripheral wall. The end face of the eccentric hole opener may be flat or conical or parabaloidal.

In use, the eccentric hole opener will form one of the units of the bottom hole assembly. Typically the hole opener will be connected to a centralising means. This may be integral with the eccentric hole opener and/or may take the form of a stabiliser and/or a roller reamer and/or a pilot bit any of which may co-operate with a pilot hole, previously drilled or drilled by the pilot bit while the hole is being opened. Where the eccentric hole opener is used in a tool having a pilot bit, the arrangement of cutting elements on the hole opener may be adjusted to take into account the cutting forces generated by the cutting elements of the bit. For example cutting elements may be present on one side only of the pilot bit, and the cutting elements of the eccentric hole opener may be disposed diametrically opposite those of the pilot bit.

The relationship between the diameters of: the pilot hole, the hole to be made, and the bore through

which the tool must pass may be such that there is not room for cutting elements all round the eccentric periphery. In this case a beneficial partial lateral force balance may be obtained by locating the cutting elements as far round the eccentric periphery as possible. Further improvement in this case can be obtained by variation of the spacing and/or orientation of the cutting elements.

An arrangement within the scope of the invention is to distribute the cutters unevenly about the axis, predominantly on one side where there is more room, and to orient the cutting elements to introduce a side rake angle to reduce the lateral imbalance of the cutting forces.

Combinations of the above arrangements are possible. The cutting elements need not be located in the same horizontal plane and may be on for example a cone or parabaloid coaxial with the centralising means.

The cutting elements may be formed of any suitable material, e.g. natural diamond, synthetic diamond and/or tungsten carbide. They may be polycrystalline diamond compacts. They may take the form of rollers carrying teeth, as in roller cone rock bits.

In order that the invention may be well understood, it will now be described with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is an elevation of an eccentric hole opener of the invention,

Figure 2 is an end view in the direction of arrow A on Figure 1,

Figure 3 is a plan view showing the eccentric hole opener of Figures 1 and 2 in a bore,

Figure 4 is a perspective view of another eccentric hole opener,

Figure 5 is a side view of another eccentric hole opener, and

Figure 6 is an end view from below of the tool of Figure 5; and

Figure 7 is a view as Figure 5 but of another tool.

The hole opener of Figures 1 and 2 comprises a stabiliser unit 1, an eccentric hub 2 carrying cutting elements 9 and 10 and an upper fishing neck or tong neck 3. At each end the tool has a tool joint thread connection 4 and 14 and the tool has a through bore 5 to pass drilling fluid. The stabiliser unit 1 has a number of smooth lands 6 partially protected by wear pads of

tungsten carbide or other hard material.

The cutting elements 9, which may be natural diamond or the like but preferably are polycrystalline diamond compact cutters, are set into the peripheral portion P of the leading face of the eccentric hub. A further few cutting elements 10 extend up the side face of the hub 2 to trim the gauge of the opened hole. The trailing end of the hub 2 is chamfered as at 11 for guiding of the tool when it is removed from a well, particularly through the well head. The neck 3 is used for rig tongs in making up the tool joints 4 and 14. The neck 3 is shaped for fishing, should the tool be lost in a hole.

In use, a rotary pilot drill bit having a diameter very close to that of the stabiliser 6 is connected to the thread connection 4 and the thread connection 14 is connected to the lowest drill collar of the assembly. The assembly is run into the hole and driven like a rotary drill bit. The pilot bit drills ahead and the cutters 9 cut or abrade the bottom of the enlarged portion of the hole so extending it at the same rate. The cutting elements 10 trim the enlarged hole to the full diameter.

Because of the disposition of the cutting elements 9 around the periphery of the portion P there is a low rate of wear on the stabiliser unit 1, minimal damage to the walls of the pilot hole by the stabiliser, thus ensuring that the tool rotates about the desired axis, improving the hole geometry, and lowering friction torque. A further advantage of the tool is that all the drilling fluid which passes through the pilot bit is forced to pass close by the cutting elements, giving improved cleaning and cooling. In previous blade type eccentric hole openers, much of the drilling fluid passes freely between the blades.

Nozzles (not shown) may be provided to pass additional clean drilling fluid to the bottom of the enlarged hole as in other hole openers.

The tool of Figures 1 and 2 is of especial value in passing through a well head having a bore diameter of 386 mm, drilling a pilot hole 211 mm and enlarging the diameter to about 445 mm.

Figure 3 shows diagrammatically a tool in a bore 20 how the cutting elements are oriented with a side rake angle to balance the lateral forces in cases where there is insufficient room to spread the cutting elements

all around the periphery of the tool. Only three cutters are shown for clarity, but more may be present. The cutter 9a has zero side rake and the force exerted on it by the formation is represented as the vector A. The side rake angle of cutter 9b swings the cutting force vector B giving a component in opposition to the force A. A similar component D combines with C to partly or largely laterally balance the force A.

In the embodiment of Figure 4, the eccentric hole opener 40 comprises a lower frustoconical body 41 having ~~vertically disposed~~ rows 43 of cutting elements 42. An integrally formed upper frustoconical body 44 is present to guide the hole opener in its removal from the bore. Although the elements are shown in vertical rows 43, this arrangement could be replaced by another configuration, e.g. a helix. Because the cutting elements extend around the circumference of the hole opener 40, the imbalance components of the horizontal cutting forces generated in use of the tool is reduced.

In the embodiments of Figures 5 and 6, the bottom hole assembly comprises a pilot bit 51 integrally formed with an eccentric hole opener 52. The bit has rows of cutting elements 53 arranged in known manner.

As best seen in Figure 6, the hole opener has a generally circular side portion X which merges with a side portion Y of a radius equal to that of the enlarged hole being drilled. The lower end face 54 of the hole opener 52 slopes across the major axis of the bit 51, as best seen in Figure 5. Cutting elements 55 are arranged in banks at the side portion X of the face 54, in an arrangement to balance the cutting forces generated by the elements 54 at the periphery of the side portion Y. Further cutting elements 56 are present in the side face of the portion Y as seen in Figure 5. Drilling mud exits via the outlet 57 of the pilot bit 51 and is forced up waterways W past the cutting elements 53 of the bit and the cutting elements 55 of the hole opener.

In the embodiment of Figure 7, the bottom hole assembly comprises a pilot bit 71 integrally formed with an eccentric hole opener 72. Rows of cutting elements 73 are present on the bit on one side only, the left hand side as seen in Figure 7. The hole opener has a generally circular side portion which merges with a side portion of a radius equal to that of the enlarged hole being drilled. The lower end face 74 of the hole opener 72 slopes across the major axis of the bit 71, and

cutting elements 75 are arranged in banks on the right hand side of the bit in an arrangement to balance the cutting forces generated by the elements 73. In this way the hole opener is balanced even though the elements 73, 75 are vertically spaced apart up the tool.

It will be appreciated that when the tool is rotated eccentrically this is with respect to the local axis of rotation. Also, in the calculation of the imbalance this is with respect to the scalar sum of the horizontal cutting forces.

CLAIMS

1. A tool for use in underground formations comprising an annular body having connecting means at least one end whereby it may be connected to other units of the bottom hole assembly of a drill string, the connecting means being arranged such that the body is mounted eccentrically on the bottom hole assembly, cutting elements being present on the body characterised in that the cutting elements (9; 43; 55; 75) are distributed about an end face (P) of the body (2; 41; 52; 72) in an arrangement to reduce the imbalance of the lateral components of the cutting forces generated in use of the hole opener.

2. A tool according to Claim 1 characterised in that the cutting elements are so arranged that the imbalance component is less than 50% of the horizontal cutting force.

3. A tool according to Claim 2 characterised in that the cutting elements are arranged such that the imbalance component is about 20% of the horizontal cutting force.

4. A tool according to Claims 1, 2 or 3 characterised in that the cutting elements are formed of natural diamond,

synthetic diamond and/or tungsten carbide, polycrystalline diamond compacts or comprise rollers carrying teeth.

5. A tool accordingto Claims 1, 2, 3 or 4 characterised in that the body is substantially circular or oval as seen in plan and in that the cutting elements are distributed substantially evenly about the body close to the periphery of the end face.

6. A tool according to any of Claims 1 to 5 characterised in that the cutting elements are oriented to have a side rake angle arranged to reduce the lateral imbalance of the cutting forces.

7. A tool according to any preceding Claim characterised in that cutting elements present on the end face to open the hole and cutting elements (10, 56, 76) are present to the rear of the end face to trim the hole wall.

8. A tool according to any of Claims 1 to 5 characterised in that the body is generally frusto-conical (41, Figure 4) and in that the cutting elements (42) are arranged in ~~vertically disposed~~ rows (43).

9. A tool according to any of Claims 1 to 5 characterised in that the body (52; 72) is connected to

a pilot bit (51, Figures 5 and 6, and 71, Figure 7), and has a generally circular side portion (X) which merges with a side portion (Y) of a radius substantially equal to that of the bore being drilled and in that the cutting elements (55) extend across the sloping end face of the body (52).

10. A tool according to Claim 9 characterised in that the bit (71) has bit cutting elements (73) predominantly on one side of the bit and in that the eccentric body (72) has cutting elements (75) predominantly on the diametrically opposite side of the tool.

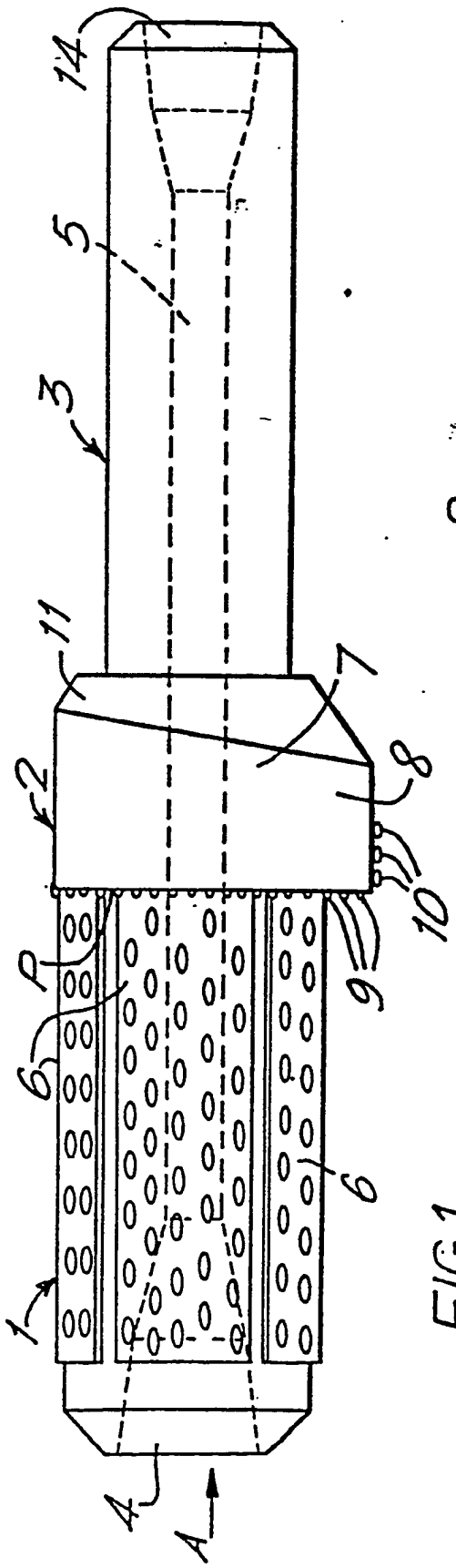


FIG.1.

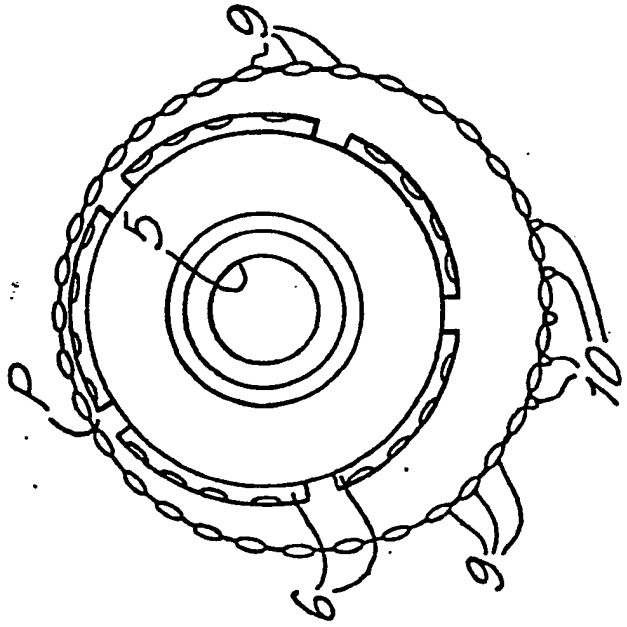


FIG.2.

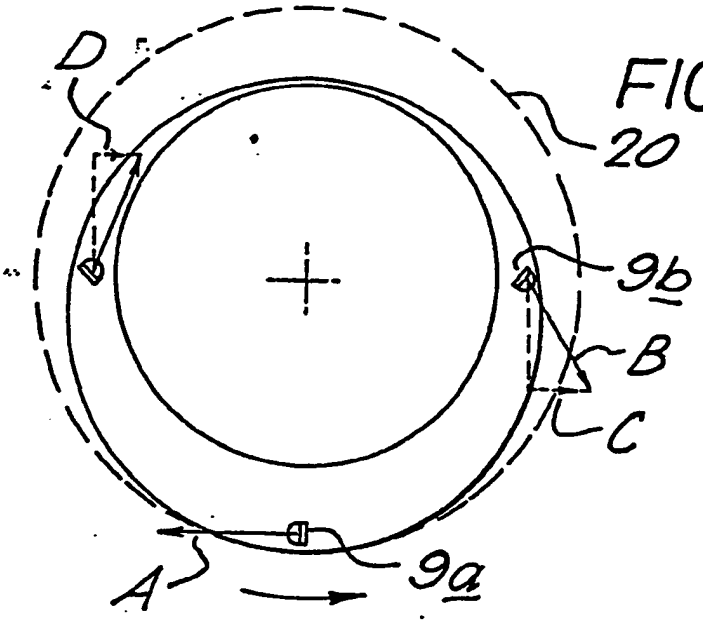


FIG.3.

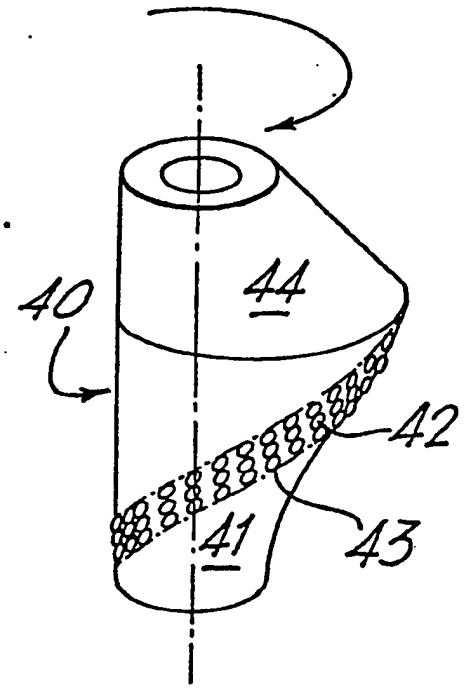
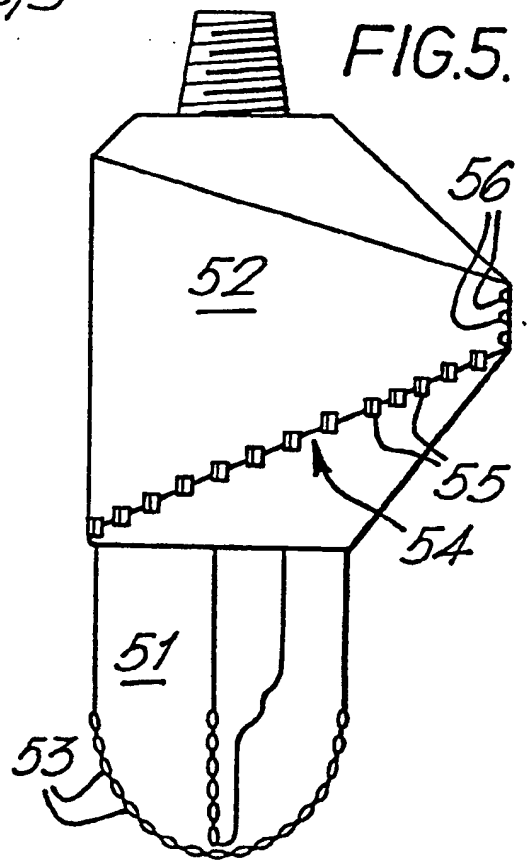


FIG.4.

FIG.5.



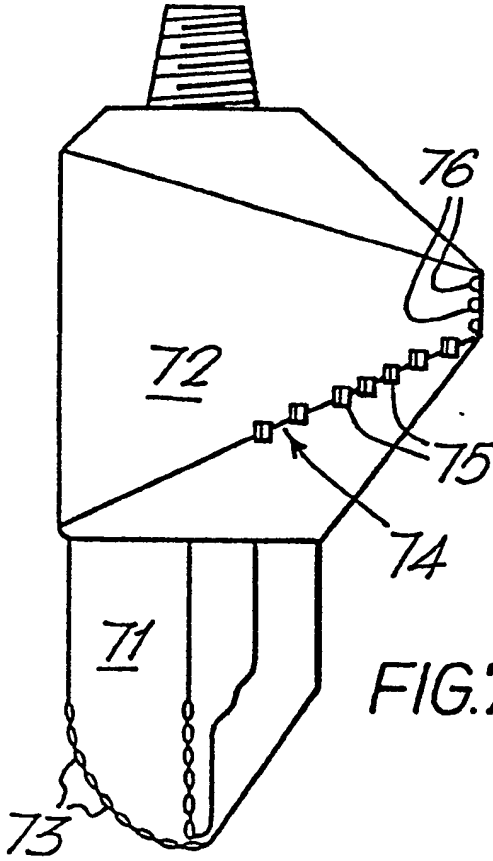


FIG.7.

FIG.6.